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PHILOSOPHICAL *TRANSACTIONS.*

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An Account *Of a* New *kind of* Baroſcope, *which may be called* Statical; *and of ſome Advantages and Conveniencies it hath above the* Mercurial: *Communicated, ſome while ſince, by the Honourable* Robert Boyle.

AS for the *New* kind of *Baroſcopes*, which, not long agoe,* I intimated to you, that my haſte would not permit me to give you an account off; ſince your Letters acquaint me, that you ſtill deſign a Communicating to the

*See *Num.*11.*p.* 185. *Phil. Tranſactions.*

Curious as much Information, as may be, in reference to *Baroſcopes*; I ſhall venture to ſend you ſome Account of what I did but name (in my former Letter) to you.

Though by a Paſſage, you may meet with in the 19th and 20th Pages of my *Thermometrical Experiments and Thoughts*, you may find, that I did ſome years agoe think upon this New kind of Baroſcope; yet the Changes of the Atmoſphere's Weight not happening to be then ſuch, as I wiſh'd, and being unwilling to deprive my ſelf of all other uſe of the exacteſt Ballance *, that I (or perhaps any man) ever had, I confeſs to you, that ſucceſſive avocations put this attempt for two or three years out of my thoughts; till afterwards returning to a place, where I chanc'd to find two or three pairs of Scales, I had left there, the ſight of them brought it into my mind; and though I were then unable to procure exacter, yet my deſire to make the Experiment ſome amends for ſo long a neglect, put me upon conſidering, that if I provided a *Glaſs-buble*, more than ordinary large and light, even ſuch Ballances, as thoſe, might in ſome meaſure perform, what I had tried with the ſtrangely nice ones above-mention'd.

* *The* Scales *here meant were before competent Eye-witneſſes made to turn manifeſtly with the thouſandth part of a grain.*

I cauſed then to be blown at the Flame of a Lamp ſome *Glaſs-bubles* as large, thin and light, as I could then procure, and chooſing among them one, that ſeem'd the leaſt unfit for my turn, I counterpoiſed it in a pair of Scales, that would looſe their *Æquilibrium* with about the 30th part of a Grain, and were ſuſpended at a Frame. I placed both the Ballance and the Frame by a good Baroſcope, from whence I might learn the preſent weight of the Atmoſphere. Then leaving theſe Inſtruments together; though the Scales, being no nicer than I have expreſs'd, were not able to ſhew me all the Variations of the Air's weight, that appear'd in the *Mercurial* Baroſcope, yet they did what I expected, by ſhewing me variations no greater, than alter'd the height of Quickſilver half a quarter of an Inch, and perhaps much ſmaller, than thoſe: Nor did I doubt, that, if I had had either tender Scales, or the means of ſupplying the Experiment with convenient accommodations, I ſhould have diſcerned

ſcerned far ſmaller Alterations of the Weight of the Air, ſince I had the pleaſure to ſee the Buble ſometimes in an *æquilibrium* with the counterpoiſe; ſometimes, when the Atmoſphere was high, preponderate ſo manifeſtly, that the Scales being gently ſtirr'd, the Cock would play altogether on that ſide, at which the Buble was hung; and at other times (when the Air was heavier) that, which was at the firſt but the Counterpoiſe, would preponderate, and, upon the motion of the Ballance, make the Cock vibrate altogether on its ſide. And this would continue ſometimes many daies together, if the Air ſo long retain'd the ſame meaſure of gravity; and then (upon other changes) the Buble would regain an *æquilibrium*, or a preponderance; ſo that I had oftentimes the ſatisfaction, by looking firſt upon the *Statical* Baroſcope (as for diſtinctions ſake it may be call'd) to foretell, whether in the *Mercurial* Baroſcope the Liquor were high or low. Which Obſervations though they hold as well in Winter, and ſeveral times in Summer (for I was often abſent during that ſeaſon) as the Spring, yet the frequency of their Viciſſitudes (which perhaps was but accidental) made them more pleaſant in the latter of theſe ſeaſons.

So that, the matter of Fact having been made out by variety of repeated Obſervations, and by ſometimes comparing ſeverall of thoſe new *Baroſcopes* together, I ſhall add ſome of thoſe Notes about this Inſtrument, which readily occur to my memory, reſerving the reſt till another opportunity.

And *Firſt*, if the ground, on which I went in framing this *Baroſcope*, be demanded, the anſwer in ſhort may be; 1. That, though the Glaſs-buble, and the [†]Glaſs-counterpoiſe, at the time of their firſt being weigh'd, be in the Air, wherein they both are weigh'd, exactly of the ſame weight; yet they are nothing near of the ſame bulk; the Buble, by reaſon of its capacious cavity (which contains nothing but Air, or ſomething that weighs leſs than Air) being perhaps a hundred or two hundred times (for I have not conveniency to meaſure them) bigger than the Metalline counterpoiſe. 2. That according to a *Hydroſtatical* Law (which you know I have lately had occaſion to make out) If two Bodies of equal gravity, but unequal bulk come to be weigh'd in another *Medium*, they will be no longer equiponderant; but if the new *Medium* be heavier, the greater Body, as being lighter in *Specie*, will looſe more of its weight, than the leſſer and more compact; but if the new *Medium* be lighter than the firſt, then the bigger Body will outweigh the leſſer: And this diſparity, ariſing from the change of *Medium*'s, will be ſo much the greater, by how much the greater inequality of bulk there is between the Bodies formerly equiponderant. 3. That, laying theſe two together, I conſider'd, that 'twould be all one, as to the effect to be produced, whether the Bodies were weighed in *Medium*'s of differing gravity, or in the ſame *Medium*, in caſe its (*ſpecifick*) gravity were conſiderably alter'd: And conſequently, that ſince it appear'd by the *Baroſcope*, that the weight of the Air was ſometimes heavier, and ſometimes lighter, the alterations of it, in point of gravity, from the weight, it was off at firſt counterpoiſing of the Buble of it, would *unequally* affect ſo large and hollow a Body, as the Buble, and ſo ſmall and denſe a one, as a Metallin weight: And when the Air by an increaſe of gravity ſhould become a heavier *Medium*, than before, it would buoy up the Glaſs more than the Counterpoiſe; and if it grew lighter, than it was at firſt, would ſuffer the former to preponderate: (The Illuſtrations and Proof can ſcarce be added in few words; but, if it be deſired, I may, God permitting, ſend you them at my next leaſure:) And though our Engliſh Air be about a thouſand times lighter, than water, the difference in weight of ſo little Air, as is but equal in bulk to a Buble, ſeem'd to give ſmall hopes, that it would be ſenſible upon a Ballance; yet, by making the Buble very large and light, I ſuppoſed and found the Event, I have already related.

Secondly, The hermetically ſeal'd Glaſs-buble, I employed, was of the bigneſs of a ſomewhat large *Orange*, and weigh'd about 1. drachme and 10. grains. But I thought it very poſſible, if I had been better furniſh't with conveniencies (wherein I afterwards found, I was not miſtaken) to make (among many, that might be expected to miſcarry) ſome, that might be preferable to this, either for capacity or lightnes, or both; eſpecially if care be taken, that they be not ſeal'd up, whilſt they are too hot. For, though one would think, that it were advantagious

tagious to rarify and drive out the Air as much as is poſſible, becauſe in ſuch ſeal'd Bubles the Air it ſelf (as I have elſewhere ſhewn) has a weight; yet this advantage countervails not the inconvenience of being obliged to increaſe the weight of the Glaſs, which when it includes highly rarified Air, if it be not ſomewhat ſtrong, will be broken by the preſſure of the External Air, as I have ſufficiently tryed.

Thirdly, I would have tryed, whether the *Dryneſs* and *Moiſture* of the Air would in any meaſure have alter'd the weight of the Buble, as well as the Variation of Gravity produced in the *Atmoſphere* by other cauſes; but the extraordinarily conſtant abſence of Fogs, kept me from making Obſervations of this kind; ſave that one morning early, being told of a miſt, I ſent to ſee (being my ſelf in bed) whether it made the Air ſo heavy as to buoy up the Buble; but did not learn, that that miſt had any ſenſible operation on it.

Fourthly, By reaſon of the difficulties and caſualties, that may happen about the procuring and preſerving ſuch large and light Bubles, as I have been lately mentioning; it may in ſome caſes prove a convenience to be inform'd, That I have ſometimes, inſtead of one ſufficiently large Buble, made uſe of two, that were ſmaller. And, though a ſingle Buble of competent bignes be much preferable, by reaſon that a far leſs quantity and weight of Glaſs is requiſite to comprize an equal capacity, when the Glaſs is blown into a ſingle Buble, than when it is divided into two; yet I found, that the employing of two inſtead of one, did not ſo ill anſwer my exſpectations, but that they may for a need ſerve the turn inſtead of the other; than which they are more eaſier to be procured: And if the Ballance be ſtrong enough to bear ſo much Glaſs, without being injur'd: by employing two or a greater number of large Bubles, the effect may be more conſpicuous, than if only a ſingle Buble (though a very good one) were employed.

This inſtrument may be much improved by divers Accommodations. As

Firſt, There may be fitted to the *Anſa* (or Checks of the Ballance) an Arch (of a Circle) divided into 15. or 20. deg. (more or leſs, according to the goodneſs of the Ballance) that the Cock reſting over againſt theſe Diviſions, may readily and without Calculation ſhew the quantity of the Angle, by which, when the ſcales propend either way, the Cock declines from the Perpendicular, and the beam from its Horizontall paralleliſm.

Secondly, Thoſe, that will be ſo curious, may, inſtead of the Ordinary Counterpoiſe (of Braſs) employ one of Gold, or at leaſt of Lead, whereof the *latter* being of equal weight with Braſs, is much leſs in Bulk, and the *former* amounts not to half its bigneſs.

Thirdly, Theſe parts of the Ballance, that may be made of Copper or Braſs, without any prejudice to the exactneſs, will, by being made of one of thoſe Mettals, be leſs ſubject, than Steel, (which yet, if well hardned and poliſh'd, may laſt good a great while) to ruſt with long ſtanding.

Fourthly, Inſtead of the ſcales, the Buble may be hung at one end of the Beam, and only a Counterpoiſe to it at the other, that the Beam may not be burthen'd with unneceſſary weight.

Fifthly, The whole inſtrument, if placed in a ſmall Frame, like a ſquare Lanthorn with Glaſs-windows, and a hole at the top for the Commerce of the internal and external Air, will be more free from duſt, and irregular agitations; to the latter of which, it will otherwiſe be ſometimes incident.

Sixthly, This inſtrument being accommodated with a light Wheele and an Index (ſuch as have been applyed by the excellent Dr. *Chr. Wren* to open Weather glaſſes, and by the ingenious Mr. *Hook* to *Baroſcopes*) may be made to ſhew much more minute variations, than otherwiſe.

Seventhly, And the length of the Beam, and exquiſitneſs of the Ballance, may eaſily, *without* any of the foregoing helps (and much more *with* them) make the inſtrument far exacter, than any of thoſe, I was reduced to employ. And to theſe Accommodations divers others may be ſuggeſted by a farther conſideration of the nature of the thing, and a longer practice.

Though in ſome reſpects this *Statical* Baroſcope be inferior to the *Mercurial*; yet in others it has its own advantages and conveniencies above it.

And 1. It confirms *ad oculum* our former Doctrine, that the falling and riſing of the *Mercury* depends upon the varying weight of the Atmoſphere; ſince in this Baroſcope it cannot

be

be pretended, that a *Fuga vacui*, or a *Funiculus*, is the cauſe of the changes, we obſerve. 2. It ſhews, that not only the Air has weight, but a more conſiderable one, than ſome Learned men, who will allow me to have prov'd, it has ſome weight, will admit; ſince even the variation of weight in ſo ſmall a quantity of Air, as is but equal in bulk to an *Orange*, is manifeſtly diſcoverable upon ſuch Ballances, as are none of the niceſt. 3. This *Statical* Baroſcope will oftentimes be more parable, than the other: For many will finde it more eaſie, to procure a good pair of Gold-ſcales, and a Buble or two, than a long Cane ſeal'd, a quantity of *Quick-ſilver*, and all the other requiſits of the *Mercurial* Baroſcope; eſpecially if we compriſe the trouble and skill, that is requiſite to free the deſerted part of the Tube from Air. 4; And whereas the difficulty of removing the *Mercurial* Inſtrument has kept men from ſo much as attempting to do it, even to neighbouring places; the Eſſential parts of the *Scale*-Baroſcope (for the Frame is none of them) may very eaſily in a little room be carried, whither one will, without the hazard of being ſpoil'd or injur'd. 5. There is not in *Statical* Baroſcopes, as in the other, a danger of uncertainty, as to the goodneſs of the Inſtruments, by reaſon, that in *theſe* the Air is, in ſome more, and in ſome leſs perfectly excluded; whereas in *thoſe*, that conſideration has no place. (And by the way, I have ſometimes, upon this account, been able to diſcover by our new Baroſcope, that an eſteem'd *Mercurial* one, to which I compared it, was not well freed from Air.) 6. It being, as I formerly intimated, very poſſible to diſcover *Hydroſtatically*, both the bigneſs of the Buble, and the Contents of the cavity, and the weight and dimenſions of the Glaſſie ſubſtance (which together with the included Air make up the Buble,) much may be diſcover'd by this Inſtrument, as to the Weight of the Air, *abſolute* or *reſpective*. For, when the *Quick-ſilver* in the *Mercurial* Baroſcope is either very high, or very low, or at a middle ſtation between its greateſt and leaſt height, bringing the *Scale*-Barometer to an Exact *Æquilibrium*; (I with very minute diviſions of a Graine,) you may, by watchfully obſerving, when the *Mercury* is riſen or faln juſt an inch, or a fourth, or half an inch &c. and putting in the like minute diviſions of a Grain to the lighter Scale, till you have again brought the Ballance to an exquiſit *Æquilibrium*; you may, I ſay, determine, What known weight in the *Statical* Baroſcope anſwers ſuch determinate Altitudes of the aſcending and deſcending Quick-ſilver in the *Mercurial*. And if the Ballance be accommodated with a divided Arch, or a Wheel and Index, theſe Obſervations will aſſiſt you for the future to determine readily, by ſeeing the inclination of the Cock or the degree mark'd by the Index, what pollency the Buble hath, by the change of the *Atmoſpheres* weight, acquired or loſt. Some Obſervations of this nature I watchfully made, ſometimes putting in a 64th. ſometimes a 32th ſometimes a 16th. and ſometimes heavier parts of a Grain, to the lighter Scale. But one, that knew not, for what uſes thoſe little papers were, coming to a window, where my Baroſcopes ſtood, ſo unluckily ſhook them out of the Scales, and confounded them, that he robb'd me of the opportunity of making the nice Obſervations I intended, though I had the ſatiſfaction of ſeeing, that they were to be made. 7. By this *Statical* Inſtrument we may be aſſiſted to compare the *Mercurial* Baroſcopes of *ſeveral* places (though never ſo diſtant) and to make ſome Eſtimates of the Gravities of the Air therein. As if, for inſtance, I have found by Obſervation, that the Buble, I employ, (and one may have divers Bubles of ſeveral ſizes, that the one may repaire any miſchance, that may happen to another) weigh'd juſt a Drachme, when the *Mercurial* Cylinder was at the height of 29½ inches (which in ſome places I have found a *moderate* altitude;) and that the Addition of the 16th part of a gr. is requiſite to keep the Buble in an *Æquilibrium*, when the *Mercury* is riſen an 8th, or any determinate part of an inch above the former ſtation: When I come to another place, where there is a *Mercurial* Barometer, as well freed from Air as mine (for that muſt be ſuppoſed) if taking out my *Scale* inſtrument, it appeare to weigh preciſely a Drachme, and the *Mercury* in the Baroſcope there ſtand at juſt 29½ inches, we may conclude the Gravity of the Atmoſphere not to be ſenſibly unequal in both thoſe two places, though very diſtant. And though there be no Baroſcope there, yet if there be an additional weight, as for inſtance, the 16th part of a Grain requiſite to be added to the Buble, to bring the ſcales to an *Æquilibrium*, it will appear that the Air at this ſecond place is, at that time

ſo

ſo much heavier, than the Air of the former place was, when the *Mercury* ſtood at 29$\frac{1}{2}$ inches.

But in making ſuch compariſons, we muſt not forget to conſider the Situation of the ſeveral places, if we mean to make Eſtimates not only of the weight of the Atmoſphere, but of the weight and denſity of the Air. For, though the Scales wil ſhew (as has been ſaid) whether there be a difference of weight in the Atmoſphere at the two places; yet, if one of them be in a Vale or bottom, and the other on the top or ſome elevated part of a Hill, it is not to be exſpected, that the Atmoſphere, in this latter place, ſhould gravitate as much, as the Atmoſphere in the former, on which a longer Pillar of Air does lean or weigh.

And the mention, I have made of the differing Situation of Places, puts me in mind of ſomething, that may prove another uſe of our *Statical* Baroſcope, and which I had thoughts of making tryal off, but was Accidentally hindred from the opportunity of doing it. Namely, that by exactly poyſing the Buble at the foot of a high Steeple or Hill, and carrying it in its cloſe Frame to the top, one may, by the weight requiſite to be added to Counterpoiſe there to bring the Beam to its Horizontal poſition, obſerve the difference of the weight of the Air at the bottom, and at the top; and, in caſe the Hill be high enough, at ſome intermediate Stations. But how far this may aſſiſt men, to eſtimate the *Abſolute* or *Comparative* height of Mountains, and other elevated Places; and what other Uſes the Inſtrument may be put to, when it is duly improved; and the Cautions, that may be requiſite in the ſeveral caſes, that ſhall be propoſed, I muſt leave to more leaſure, and farther Conſideration.

The Particulars.

Of thoſe Obſervations of the Planet Mars, *formerly intimated to have been made at* London *in the Months of* February *and* March *A.* 166$\frac{5}{6}$.

To perform, what was promiſed *Num.* 11. of theſe Papers, *pag.* 198; 'tis thought fit now to publiſh the Particular Obſervations, concerning the ſpots in *Mars*, and their motion, as they were made with a 36 foot Teleſcope, and produced in